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(54) **GAS TURBINE EXHAUST CASE WITH ACOUSTIC PANELS**

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F01D 25/04	(2006.01)
F02C 7/20	(2006.01)
F02C 7/045	(2006.01)
F01D 25/16	(2006.01)
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See application file for complete search history.

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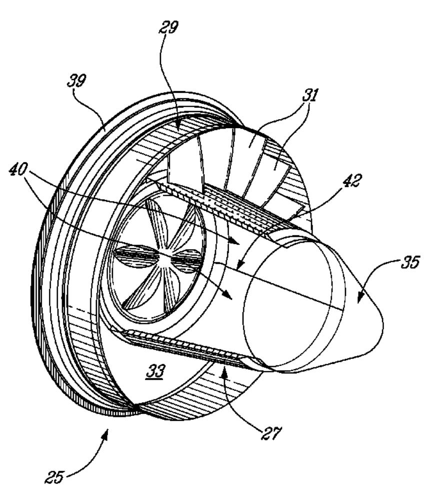
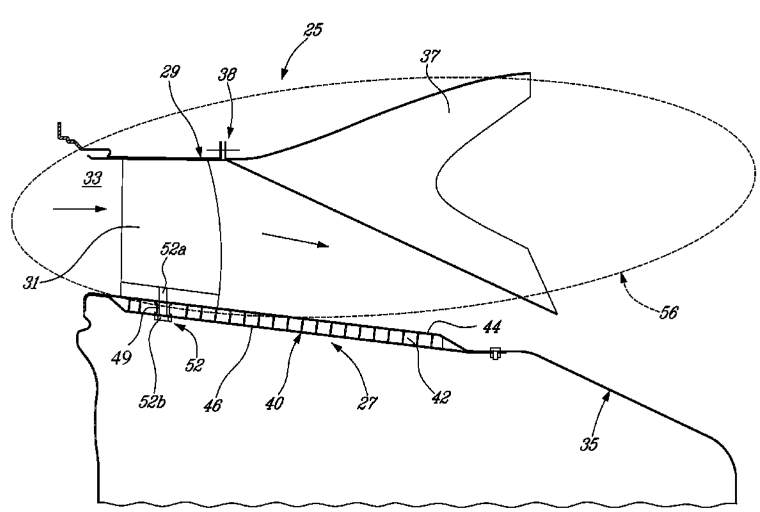
(57) **ABSTRACT**

A turbine exhaust case for a gas turbine engine has an outer shroud and an inner shroud concentrically defining therebetween an annular gaspath for channelling hot gases. A plurality of circumferentially spaced-apart turbine exhaust struts extends radially across the hot gaspath. The inner shroud may be provided in the form of an acoustic panel. The acoustic panel has a radially outwardly facing surface defining the radially inner flow boundary surface of the gaspath. The acoustic panel is mechanically fastened to the radially inner end of the struts.

17 Claims, 4 Drawing Sheets





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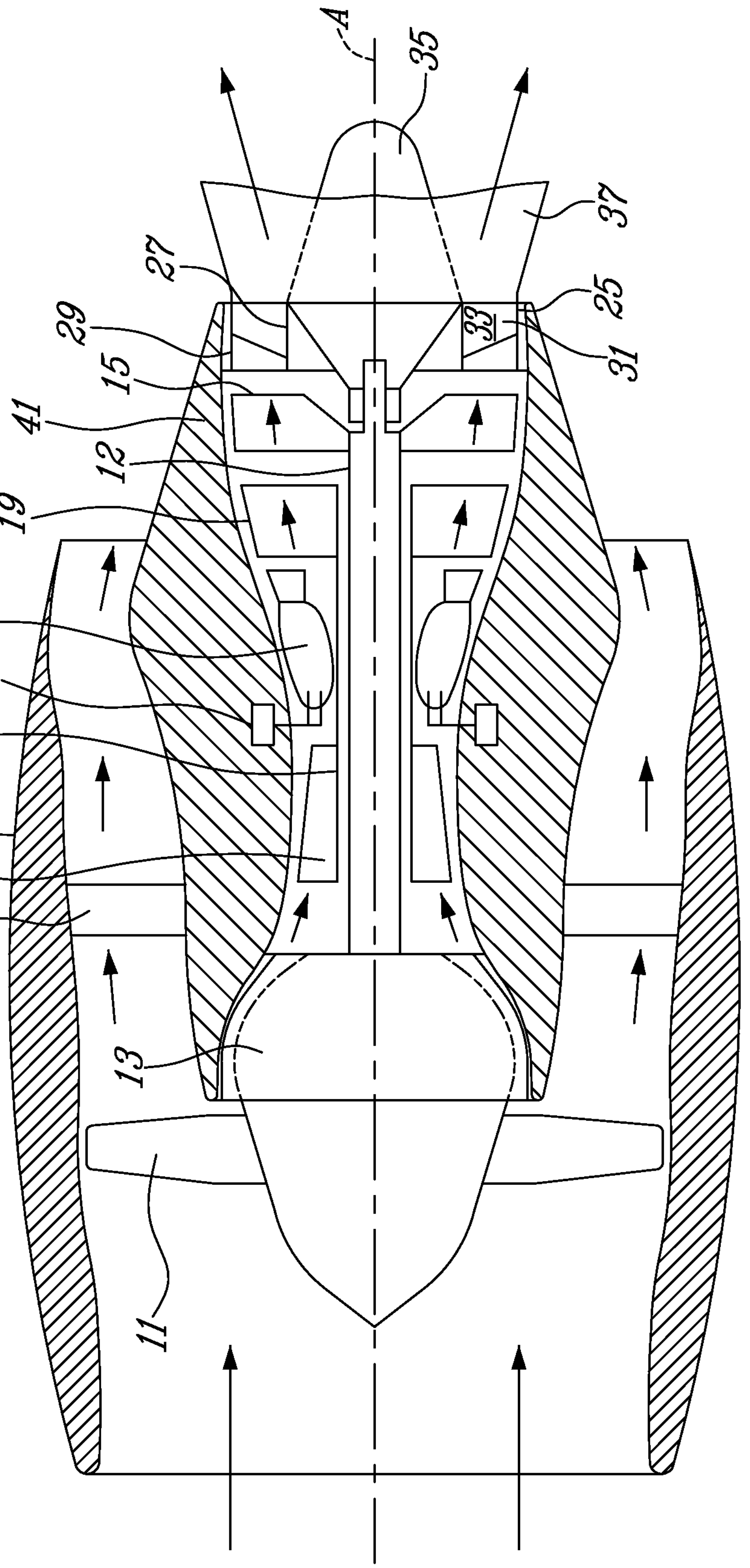

FIG-1

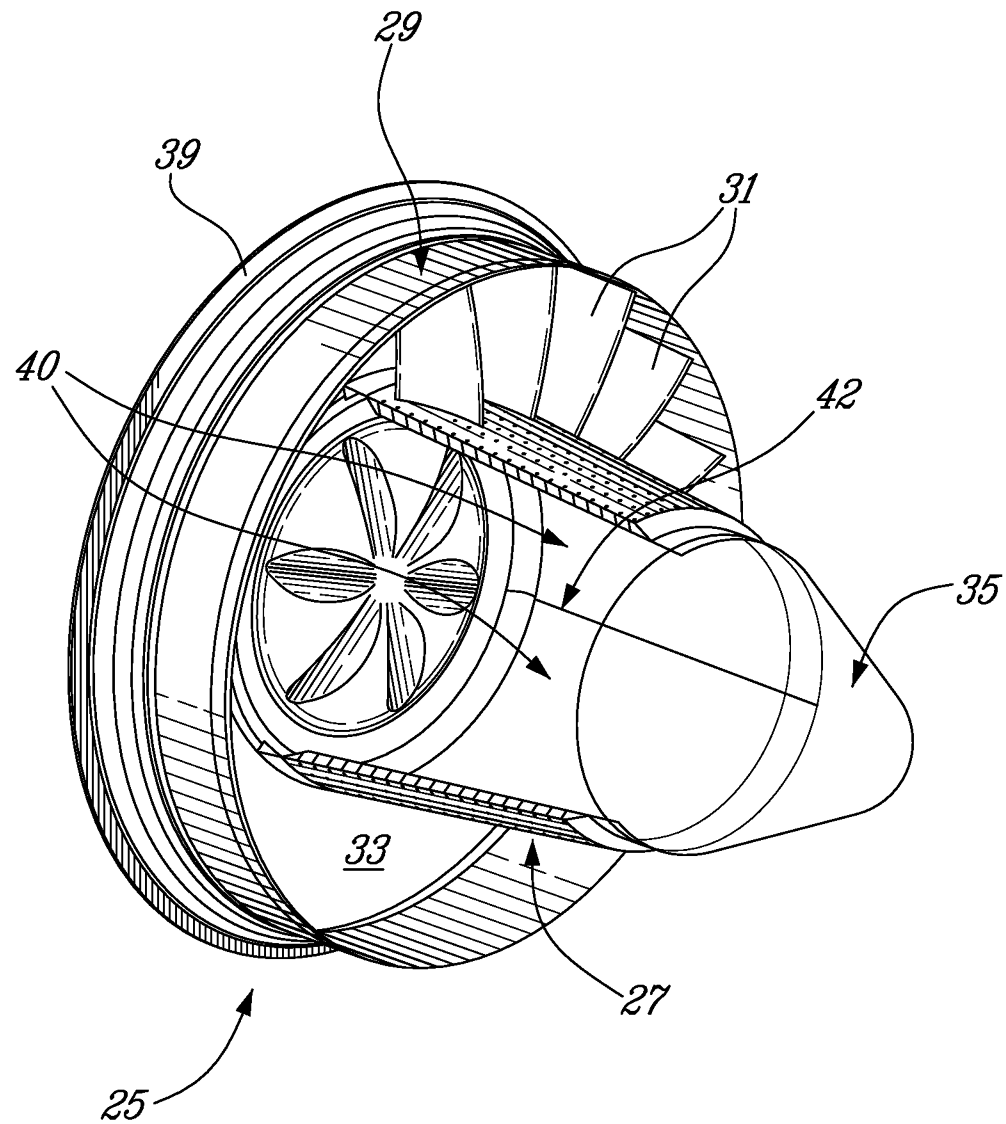

FIG. 2

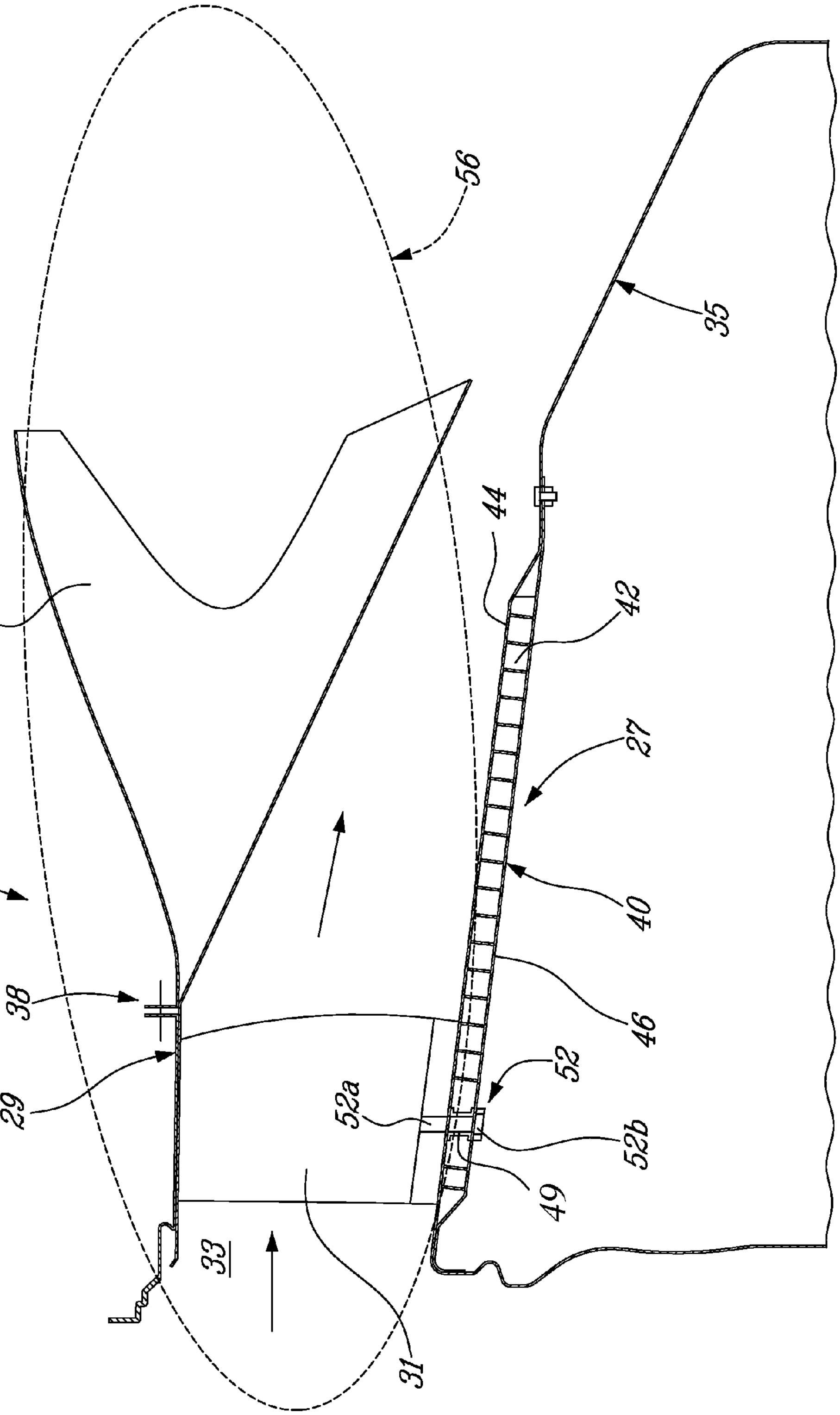

FIG. 3

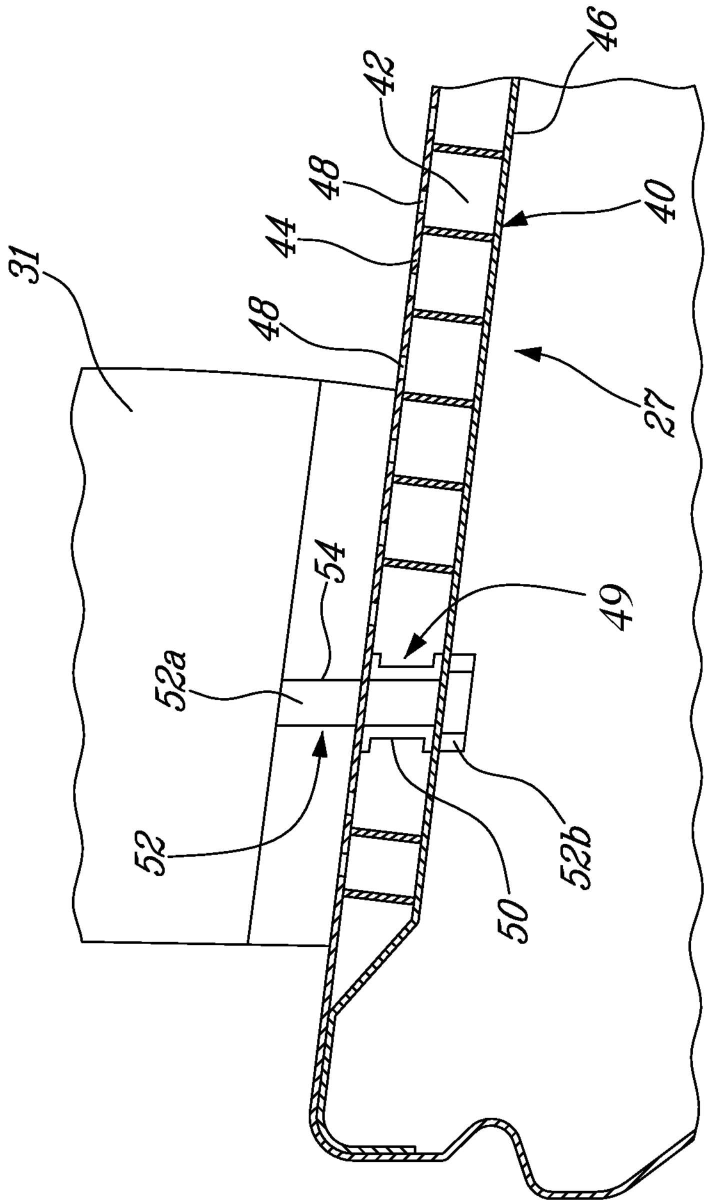

FIG-4

GAS TURBINE EXHAUST CASE WITH ACOUSTIC PANELS

TECHNICAL FIELD

The application relates generally to gas turbine engines and, more particularly, to a gas turbine exhaust case of a turbofan engine.

BACKGROUND OF THE ART

Acoustic panels typically comprise a honeycomb core layer trapped between a solid bottom skin and an upper skin. The upper skin is typically perforated with a plurality of acoustic holes to trap the sound in the alveolar cells of the honeycomb material. Accordingly, for the acoustic panels to perform satisfactorily, obstruction or contamination of the acoustic holes should be avoided. This might be challenging when the acoustic panels have to be integrated to an engine structure which necessitates the panels to be exposed to manufacturing processes, such as welding and machining. There is always a risk that some of the acoustic holes become clogged or contaminated as a result of being exposed to such subsequent manufacturing processes. Cleaning the panels afterwards can be challenging. Accordingly, the integration of acoustic panels in certain areas of gas turbine engines is still relatively limited.

SUMMARY

In one aspect, there is provided a turbine exhaust case for a gas turbine engine having an axis, the exhaust case comprising a radially outer annular shroud and a radially inner annular shroud concentrically mounted about said axis and defining therebetween an annular gaspath for channelling hot gases received from a turbine section of the engine, a plurality of circumferentially spaced-apart struts extending radially across the gaspath between the radially outer and the radially inner annular shrouds, at least one of said radially inner and outer shrouds being defined by at least one arcuate acoustic panel, said at least one arcuate acoustic panel having a radially facing surface defining a flow boundary surface of said gaspath, said at least one acoustic panel having an array of circumferentially spaced-apart fastener receiving holes extending thicknesswise therethrough, each of said fastener receiving holes being aligned with a corresponding connection hole defined in an end wall of an associated one of said struts, and a plurality of fasteners projecting radially from said fastener receiving holes of said at least one acoustic panel into said connection holes of said struts, the fasteners structurally connecting the struts to said at least one acoustic panel.

In a second aspect, there is provided a turbine exhaust case for a turbofan engine having an axis, the exhaust case comprising a radially outer annular shroud and a radially inner annular shroud concentrically mounted about said axis and defining therebetween an annular gaspath for channelling hot gases received from a turbine section of the engine, a plurality of circumferentially spaced-apart turbine exhaust struts extending radially across the gaspath between the radially outer and the radially inner annular shrouds, the radially inner shroud being defined by at least one arcuate acoustic panel, said at least one arcuate acoustic panel having a radially outwardly facing surface defining a radially inner flow boundary surface of said gaspath, said exhaust struts projecting radially outwardly from said radially outwardly facing surface of the at least one acoustic panel and being mechanically fastened at their radially inner ends to said at least one acoustic panel.

In a third aspect, there is provided a method of manufacturing a turbine exhaust case comprising: a) providing a radially outer annular shroud, b) structurally mounting a circumferential array of struts to a radially inwardly facing surface of the radially outer shroud, and then c) mechanically fastening individual acoustic panels to a radially inner end of the struts, the acoustic panels collectively forming a circumferentially segmented radially inner annular shroud.

DESCRIPTION OF THE DRAWINGS

Reference is now made to the accompanying figures, in which:

FIG. **1** is a schematic cross-section view of a turbofan gas turbine engine;

FIG. **2** is an isometric view of a turbine exhaust case, the mixer typically attached to the outer shroud of the case as well as one circumferential segment of the inner shroud of the exhaust case being omitted for clarity purposes;

FIG. **3** is a schematic cross-section of the turbine exhaust case; and

FIG. **4** is an enlarged cross-section view showing how the exhaust struts may be bolted to the acoustic panels forming the inner shroud of the turbine exhaust case.

DETAILED DESCRIPTION

FIG. **1** illustrates an example of a turbofan gas turbine engine generally comprising a housing or nacelle **10**; a low pressure spool assembly **12** including a fan **11**, a low pressure compressor **13** and a low pressure turbine **15**; a high pressure spool assembly **14** including a high pressure compressor **17**, and a high pressure turbine **19**; and a combustor **23** including fuel injecting means **21**.

Referring to FIGS. **1** to **3**, the gas turbine engine further comprises a turbine exhaust case **25** disposed immediately downstream of the last stage of low pressure turbine blades for receiving hot gases from the low pressure turbine **15** and exhausting the hot gases to the atmosphere. The turbine exhaust case **25** may comprise an annular inner shroud **27** concentrically mounted about the central axis A (FIG. **1**) of the engine, an annular outer shroud **29** concentrically mounted about the central axis A of the engine and the inner shroud **27**, a plurality of circumferentially spaced-apart struts **31** extending radially between the inner and outer shrouds **27**, **29**, thereby structurally connecting same. The struts **31** may not only serve as structural components, they may have an airfoil profile to serve as vanes for directing/straightening the incoming flow of hot gases. The struts **31** may have a hollow body to provide an internal passageway for lubrication lines and the like. As shown in FIGS. **1** and **3**, a multi-lobed mixer **37** may be attached to the aft end of the outer shroud **29**. As depicted at **38** in FIG. **3**, a flange connection may be provided for allowing the mixer **37** to be bolted to the outer shroud **29** of the turbine exhaust case **25**. A mounting flange **39** (FIG. **2**) may also be provided at the front end of the outer shroud **29** for securing the turbine exhaust case **25** to the engine case **41** (FIG. **1**) which, in turn, may be structurally connected to the nacelle **10** through a plurality struts **43** (FIG. **1**) extending radially through the bypass passage of the engine. Referring to FIGS. **1** to **3**, it may also be appreciated that a tail cone **35** may be mounted to the aft end of the inner shroud **27** of the turbine exhaust case **25**. The tail cone **35** is bolted or other suitably removably connected to the inner shroud **27**.

In operation, combustion gases discharged from the combustor **23** power the high and low pressure turbines **19** and **15**, and are then exhausted into the annular gaspath **33** defined between the inner and outer shrouds **27**, **29** of the turbine exhaust case **25**. The tangential components included in the exhaust gases may be de-swirled by the struts **31** or similar de-swirling airfoil structures which may be integrated in the turbine exhaust case **25**, and then the exhaust gases are discharged into the atmosphere through the mixer **37** which facilitates the mixing of the exhaust gases with the outer air flow from the bypass passage.

Referring now more specifically to FIGS. **2** and **3**, it can be appreciated that acoustic panel(s) is/are integrated to the inner shroud **27**. The inner shroud could be composed of a single circumferentially extending acoustic panels formed into a ring-like member. However, according to the illustrated embodiment, the inner shroud **27** is circumferentially segmented and composed of a plurality of separate/individual arcuate acoustic panels **40** assembled into a circumferentially extending band with circumferential gaps or plays **42** between adjacent panels allowing for expansion and contraction of the inner shroud **27** in response to thermally induced movement of the exhaust struts **31**. An overlap or any suitable slip joint structure (not shown) may be provided along adjoining edges of the circumferentially adjacent panels **40** to provide for a circumferentially continuous smooth flow surface for the hot gases flowing axially through the exhaust turbine case **25**. The individual acoustic panels **40** are structurally connected to the outer shroud **29** by the struts **31**. At least one strut extends from each panel **40**. The inner shroud **27** may consist of a frameless assembly of acoustic panels, the acoustic panels being structurally supported in position by the struts only. The acoustic panels **40** project axially rearwardly in a cantilever fashion from the struts **31**. This allows maximizing the surface area covered by the acoustic treatment. Also, it contributes to minimizing the weight of the engine by eliminating the need for dedicated frame members for supporting the acoustic panels.

By forming the inner shroud **27** with acoustic panel(s) **40**, an acoustic treatment can be applied substantially along the full axial length of the inner shroud **27** that is from a forward end of the exhaust turbine case **25** to an aft end thereof, thereby providing added sound attenuation as compared to conventional arrangements where the acoustic treatment is applied downstream of the turbine exhaust case **25** to the tail cone **35** or in other non-ducted exhaust areas. According to the illustrated embodiment, the acoustic panels **40** create the inner shroud **27** or the inner ducted wall of the turbine exhaust case **25**. As shown in FIGS. **2** and **3**, the radially outer surface of the panels **40** form the inner boundary flow surface of the gaspath **33** from a location upstream from the struts **31** to a location downstream thereof. As can be appreciated from FIG. **3**, the acoustic panels **40** none only extend axially upstream of the mixer **37** but also axially overlap the mixer **37** to provide sound attenuation along this ducted area as well. Such an arrangement allows providing effective sound attenuation upstream of the mixing plane where the hot gases from the engine core mixes with the fan air from the bypass passage of the engine. It can also be appreciated that by so increasing the surface area of the acoustic treatment additional sound attenuation can be obtained.

Commercially available acoustic panels of the type having a sandwich structure comprising a core layer of cellular honeycomb like material **42** disposed between two thin metal facing sheets or skins **44**, **46** may be used. As shown in FIG. **4**, the cellular honeycomb material **42** has a plurality of alveolar cells. The face skin **44**, i.e. the skin in contact with the hot gas flowing through the gaspath **33**, is typically perforated with multiple acoustic holes **48**. The density and size of acoustic holes **48** in the face skin **44** and of alveolar cells in the cellular core material **42** as well as the thickness of cellular core material **42** may be chosen by a person skilled in the art as a function of the desired acoustic performance. The back skin **46**, i.e. the skin not in contact with the hot stream of gas, may be solid (i.e. non-perforated).

The radially outer end of each strut **31** may be welded or otherwise suitably attached to the outer shroud **29**. According to one possible embodiment, the struts **31** and the outer shroud **29** are both made out of sheet metal and are welded together. As shown in FIGS. **3** and **4**, mechanical fasteners may be used to detachably structurally mount the struts **31** to the acoustic panels **40** forming the inner shroud **27**. To that end, tubular inserts **49** may be installed in corresponding holes **50** (FIG. **4**) extending thicknesswise through the acoustic panels **40** for receiving a fastener adapted to be engaged in retention relationship with the radially inner end of the struts **31**. According to the illustrated embodiment, each fastener comprises a bolt **52** which is inserted in the tubular insert **49** from within the inner shroud **27**, the bolt **52** having a threaded shank **52***a* projecting radially outwardly from the radially outer surface (i.e. face skin **44**) of the acoustic panel **40** for threaded engagement in a threaded hole **54** (FIG. **4**) defined in a radially inner end wall of the associated strut **31**. The bolt **52** is tightened until its head **52***b* bears firmly against a rim of the insert **49** the back skin **46** of the panel **40**. At least one such fastening arrangement is provided per strut **31**. According to an embodiment, more than one bolt could be used for each strut **31**. Any desired number of struts may be mounted per panel. Each panel **40** is thus provided with at least one attachment point per strut. For instance, if two circumferentially spaced-apart struts **31** are to be mounted to an acoustic panel **40**, at least two circumferentially spaced-apart tubular inserts **49** would be integrated to the panel **40**, one insert **49** for each strut **31**.

The acoustic panels **40** may be mounted to the inner radial end of the struts **31** at the end of the assembly process of the turbine exhaust case **25** to spare the acoustic panels **40** from subsequent manufacturing processes, damage and spoiling. For instance, the exhaust case **25** could be built by first forming a sheet metal ring to form the outer shroud **29**. Thereafter, the radially outer end of the struts **31** could be welded to the outer shroud **29**. At this stage, the mixer **37** can also be attached to the outer shroud **29**. Finally, the arcuate acoustic panels **40** can be mounted to the case sub-assembly **56** (FIG. **3**) formed by the outer shroud **29**, the struts **31** and the mixer **37** by bolting the acoustic panels **40** to the radially inner end of the struts **31** to form the radially inner shroud **27** of the exhaust case **25**. In this way, the acoustic panels **40** are less exposed to manufacturing processes which are susceptible to obstruct their acoustic holes **48**. In fact, the turbine exhaust case **25** can be manufactured without substantially exposing the acoustic panels **40** to subsequent manufacturing processes. This also provides for the mounting of the struts **31** directly to the acoustic panels **40**. Also, the possibility of readily removing the panels **40** of the inner shroud **27** from the struts **31** improves the ability to repair the part in service.

The above description is meant to be exemplary only, and one skilled in the art will recognize that changes may be made to the embodiments described without departing from the scope of the invention disclosed. For example, the number of struts **31** per panel **40** could vary. Also it is understood that various panel constructions are contemplated and not only the above described honeycomb sandwich material. Also the mechanical fasteners used for structurally mounting the acoustic panels to the struts of the exhaust case should not be limited to bolts. For instance, rivets could be used. Other suitable mechanical fasteners are contemplated as well. It is also understood that acoustic treatment could be applied to the outer shroud **29** as per the way described hereinbefore with respect to the inner shroud **27**. Still other modifications which fall within the scope of the present invention will be apparent to those skilled in the art, in light of a review of this disclosure, and such modifications are intended to fall within the scope of the appended claims.

What is claimed is:

1. A turbine exhaust case disposed downstream of a last stage of turbine blades of a gas turbine for exhausting hot gases to the atmosphere, the engine having an axis, the exhaust case comprising a radially outer annular shroud and a radially inner annular shroud concentrically mounted about said axis and defining therebetween an annular gaspath for channeling hot gases received from the last stage of turbine blades of the engine, a plurality of circumferentially spaced-apart struts extending radially across the gaspath between the radially outer and the radially inner annular shrouds, at least one of said radially inner and outer shrouds being defined by at least one arcuate acoustic panel, said at least one arcuate acoustic panel having a radially facing surface defining a flow boundary surface of said gaspath, the at least one arcuate acoustic panel having an acoustic treatment including a core layer of cellular honeycomb like material and a plurality of acoustic holes defined in the radially facing surface defining the flow boundary surface, said at least one acoustic panel having an array of circumferentially spaced-apart fastener receiving holes extending thicknesswise therethrough, each of said fastener receiving holes being aligned with a corresponding connection hole defined in an end wall of an associated one of said struts, and a plurality of fasteners projecting radially from said fastener receiving holes of said at least one acoustic panel into said connection holes of said struts, the fasteners structurally connecting the struts to said at least one acoustic panel.

2. The turbine exhaust case defined in claim **1**, wherein each said fastener includes a bolt threadably engaged into said connection hole of a corresponding one of said struts.

3. The turbine exhaust case defined in claim **1**, wherein each said fastener includes a bolt having a threaded shank and a head, the head of said bolt bearing against a radially inwardly facing side of the at last one acoustic panel, the radially inner shroud being defined by said at least one acoustic panel.

4. The turbine exhaust case defined in claim **1**, wherein each of said fastener receiving holes comprises a passage defined in a tubular insert integrated to said at least one acoustic panel.

5. The turbine exhaust case defined in claim **1**, wherein said at least one acoustic panel comprises a plurality of circumferentially adjoining acoustic panels which collectively form the radially inner annular shroud, at least one struts being structurally connected to each of said plurality of acoustic panels.

6. The turbine exhaust case defined in claim **1**, wherein said at least one acoustic panel comprises a frameless assembly of circumferentially adjoining acoustic panels, said frameless assembly of circumferentially adjoining acoustic panels forming said radially inner annular shroud, said acoustic panels being structurally supported in a ring like configuration by said struts and without any other underlying supporting structure.

7. A turbine exhaust case for disposed downstream of a last stage of turbine blades of a turbo fan engine for exhausting hot gases to the atmosphere, the engine having an axis, the exhaust case comprising a radially outer annular shroud and a radially inner annular shroud concentrically mounted about said axis and defining therebetween an annular gaspath for channeling hot gases received from the last stage of turbine blades of the engine, a plurality of circumferentially spaced-apart turbine exhaust struts extending radially across the gaspath between the radially outer and the radially inner annular shrouds, the radially inner shroud being defined by at least one arcuate acoustic panel, having an acoustic treatment including a core layer of cellular honeycomb like material, said at least one arcuate acoustic panel having a radially outwardly facing surface defining a radially inner flow boundary surface of said gaspath, said radially outwardly facing surface having a plurality of acoustic holes defined therein, said exhaust struts projecting radially outwardly from said radially outwardly facing surface of the at least one acoustic panel and being mechanically fastened at their radially inner ends to said at least one acoustic panel.

8. The turbine exhaust case defined in claim **7**, wherein the exhaust struts have radially outer ends, and wherein said radially outer ends are welded to said radially outer annular shroud.

9. The turbine exhaust case defined in claim **7**, wherein said at least one acoustic panel is only supported from a radially outer side thereof, the exhaust struts supporting all the weight of said at least one acoustic panel.

10. The turbine exhaust case defined in claim **7**, wherein the at least one acoustic panel projects axially rearwardly from the exhaust struts in a cantilever fashion.

11. The turbine exhaust case defined in claim **7**, wherein said radially inner ends of said struts each comprise a radially inwardly facing end wall defining at least one threaded hole for threading engagement with a threaded fastener extending thicknesswise through said at least one acoustic panel.

12. The turbine exhaust case defined in claim **11**, wherein said threaded fastener comprises a bolt engaged with a tubular insert integrated to said at least one acoustic panel.

13. The turbine exhaust case defined in claim **12**, wherein said bolt has a threaded shank projecting radially outwardly from the radially outwardly facing surface of the at least one acoustic panel.

14. A method of manufacturing a turbine exhaust case configured for mounting downstream of a last stage of turbine blades of a gas turbine engine, the method comprising: a) providing a radially outer annular shroud, b) structurally mounting a circumferential array of struts to a radially inwardly facing surface of the radially outer shroud, and then c) mechanically fastening individual acoustic panels to a radially inner end of the struts, the acoustic panels collectively forming a circumferentially segmented radially inner annular shroud, each individual acoustic panel having a radially outwardly facing surface defining a plurality of acoustic holes and a core layer of cellular honeycomb like material.

15. A method as defined in claim **14**, wherein step c) comprises bolting the acoustic panels to the struts.

16. A method as defined in claim **14**, wherein step c) comprises cantilevering the acoustic panels from said struts.

17. A method as defined in claim **14**, wherein step c) comprises inserting a bolt from a radially inner side of the acoustic panels in each of a plurality of tubular inserts integrated to the acoustic panels, and threadably engaging the bolt in threaded hole defined in a radially inwardly facing end wall of each strut.

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